(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
13 March 2003 (13.03.2003)

PCT

(10) International Publication Number
WO 03/021031 A1

(51) International Patent Classification[7]: D06M 13/00, C07F 9/54, 9/50

(21) International Application Number: PCT/GB02/03907

(22) International Filing Date: 23 August 2002 (23.08.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

0121246.3	1 September 2001 (01.09.2001)	GB
0208087.7	9 April 2002 (09.04.2002)	GB
0214337.8	21 June 2002 (21.06.2002)	GB

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(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 03/021031 A1

(54) Title: PHOSPHORUS COMPOUNDS

$$[Y_n P^{\oplus} (CH_2OH)_{4-n}]X^- \qquad (I)$$

(57) Abstract: Phosphonium compounds having the general formula (I), wherein n is a positive integer of from 1 to 4; X is an anion; and Y is an organic residue comprising a hydrophilic group; and phosphine compounds having the general formula (II) $Y_nP(CH_2OH)_{3-n}$, wherein n is a positive integer of from 1 to 3; and Y is an organic residue comprising a hydrophilic group. A method for the production of phosphorous compounds according to the above formula (I) and formula (II) and examples of uses of these compounds, including as crosslinking agents in tanning, as biocides and as iron sulphide/scale dissolvers.

PHOSPHORUS COMPOUNDS

This invention relates to phosphorus compounds and in particular to phosphonium compounds comprising the reaction product of a tetrakis(hydroxyorgano) phosphonium salt, a base and an organic acid. This invention also relates to the corresponding phosphine compounds formed by reaction of the above phosphonium compounds with bases. The present invention also relates to a method for the production of such compounds and to their use in a wide variety of applications.

The phosphorus compounds of the present invention have one or more hydroxymethyl groups and one or more hydrophilic groups covalently bonded to the phosphorus atom.

It is known from DE-AS-1045401 to produce phosphorus compounds by reacting tris(hydroxymethyl)phosphine (THP) with aliphatic α,β unsaturated carboxylic acids, esters or amides, if necessary in the presence of water, and/or of water-miscible organic solvents and/or acids.

However, THP, and its solutions in water, are unstable and will slowly decompose at ambient temperature to yield flammable materials such as hydrogen. THP can therefore require elaborate and costly handling. We have found that the disadvantages associated with the handling of THP can be avoided by starting from a tetrakis(hydroxyorgano) phosphonium salt (commercially available as a stable solution in water).

According to a first aspect the present invention provides a phosphonium compound having the general formula (I):

$$\left[Y_n P^{\oplus} (CH_2OH)_{4-n} \right] X^- \qquad (I)$$

wherein n is a positive integer of from 1 to 4; X is an anion; and Y is an organic residue comprising a hydrophilic group.

The hydrophilic group, for example, may be selected from unsaturated or saturated, aromatic or aliphatic, derivatives of C_1 to C_{10} carboxylic acids, phosphonic acids, sulphonic acids, acid phosphates, monohydric or polyhydric alcohols.

Suitably, Y may be selected from C_1 to C_{10} groups containing polyethylene glycol and/or polypropylene glycol moieties.

General formula (I) shows group "Y" in its unionised form. There will be analogous formulae, readily apparent to those skilled in the art, which represent the ionised forms.

The anion X may be, for example, chloride or sulphate. Alternatively, X may represent any other anion (which results in the product of formula (I) being water-soluble) including for example, bromide, iodide, phosphate, acetate, oxalate, citrate, borate, chlorate, nitrate, fluoride, carbonate and formate.

In a second aspect, the present invention provides a phosphine compound having the general formula (II):

$$Y_n P \quad (CH_2OH)_{3-n} \qquad (II)$$

wherein n is a positive integer of from 1 to 3; and Y is as described for formula (I). Such phosphines can typically be generated by action of a base on the phosphonium compound.

A compound of formula (I) or formula (II) may be the reaction product of a tetrakis(hydroxyorgano) phosphonium salt, a base and an unsaturated or saturated, aromatic or aliphatic, C_1 to C_{10} carboxylic acid, phosphonic acid, sulphonic acid, acid phosphate or monohydric or polyhydric alcohol.

Preferably the compound is the reaction product of a tetrakis(hydroxyorgano) phosphonium salt, a base and an unsaturated carboxylic acid, or an ester or salt of an unsaturated carboxylic acid.

Alternatively the compound may be the reaction product of a tetrakis(hydroxyorgano) phosphonium salt, a base and an alkyl halide containing at least one reactive halogen and at least one group which imparts hydrophilic character.

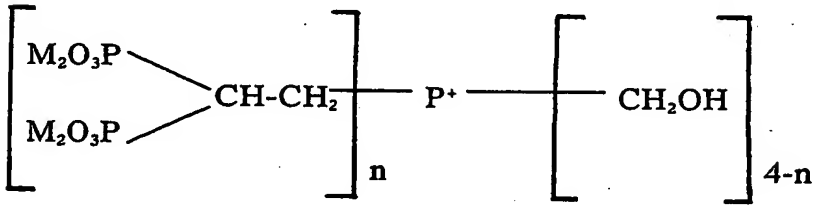
Suitably, the substituted alkyl halide comprises from one to ten carbon atoms.

The group which imparts hydrophilic character may be derived from an unsaturated or saturated, aromatic or aliphatic, C_1 to C_{10} carboxylic acid,

phosphonic acid, sulphonic acid, acid phosphate or monohydric or polyhydric alcohol.

The compounds of formula (I) and/or formula (II) may also be the reaction product of a tetrakis(hydroxy-organo) phosphonium salt, a base and vinylindene – 1, 1 – diphosphonic acid (VDPA) or a salt or an ester of VDPA.

Phosphonium compounds produced by this reaction may have the general formula (III):



(III)

wherein:

M is hydrogen, an alkali metal, an alkaline earth metal, a polyvalent metal, ammonium or a quaternised amine radical and each M may be the same or different;

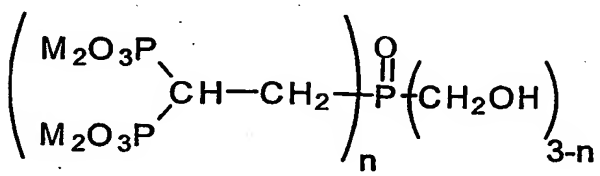
X is an anion having the same significance as in formula (I);

n is a number having a positive average value of up to 4. The number n need not be an integer.

Examples of polyvalent metals in formula (III) above include transition metals such as copper, chromium, iron, titanium, or zirconium, as well as other metals such as aluminium, while examples of quaternised amine radicals include salts derived from neutralisation with amines e.g. triethanolamine and quaternary ammonium bases e.g. tetrabutyl ammonium hydroxide.

Phosphonium compounds of formula (III) may be readily oxidised, for example, by peroxides or atmospheric oxygen, to the corresponding phosphine oxide, with the loss of formaldehyde and a proton. Phosphine oxides of this type are believed to be novel.

These phosphine oxides may be represented by the general formula (IV):



(IV)

wherein M has the same significance as in formula (III); and n is a number having a positive average value of up to 3.

In a third aspect, the present invention provides a method for the production of phosphonium compounds of formula (I) or formula (III) and/or phosphine compounds of formula (II), by the reaction of a tetrakis(hydroxyorgano) phosphonium salt (THP^+ salt), a base and an organic compound including a hydrophilic group, for example, an unsaturated or saturated, aromatic or aliphatic, C_1 to C_{10} carboxylic acid, phosphonic acid, sulphonic acid, acid phosphate or monohydric or polyhydric alcohol.

In particular, the THP^+ salt and the base may be reacted with an unsaturated carboxylic acid, or an ester or salt of an unsaturated carboxylic acid.

Phosphonium or phosphine compounds according to the present invention may also be prepared by reacting a THP^+ salt and a base with an alkyl

halide which contains at least one reactive halogen and at least one group which imparts hydrophilic character.

Preferably, the alkyl halide comprises one to ten carbon atoms. The group which imparts hydrophilic character is preferably derived from an unsaturated or saturated, aromatic or aliphatic, C_1 to C_{10} carboxylic acid, phosphonic acid, sulphonic acid, acid phosphate or monohydric or polyhydric alcohol. Alternatively, the group imparting hydrophilic character may be selected from C_1 to C_{10} groups containing polyethylene glycol and/or polypropylene glycol moieties.

The tetrakis(hydroxyorgano)phosphonium salt (THP^+ salt) is preferably a tetrakis(hydroxymethyl)phosphonium salt of formula THPX, where X is an anion as described above with reference to formula (I). The THP^+ salt may be, for example, tetrakis(hydroxymethyl)phosphonium chloride (THPC), sulphate (THPS), acetate (THPA) or phosphate (THPP).

Although it is not intended that the method according to the present invention should be construed with reference to any specific theory, it is believed that the reaction proceeds by the *in-situ* generation of tris(hydroxyorgano)phosphine (THP) under the conditions of the reaction (i.e. in the presence of a base). This type of reaction is well reported in the literature.

Preferably, the conditions of the reaction are optimised to encourage mono, rather than di or tri, substitution of the THP.

In a first preferred embodiment of the method, an unsaturated carboxylic acid, preferably a mono-carboxylic acid such as acrylic acid, is reacted with a THP^+ salt in the presence of a base.

Other unsaturated mono-carboxylic acids which may be used to make a compound of formula (I) and/or formula (II) include methacrylic acid, crotonic acid, isocrotonic acid, angelic acid and tiglic acid.

Alternatively, the unsaturated carboxylic acid may be a di-carboxylic acid such as maleic acid, fumaric acid, citraconic acid, mesaconic acid, itaconic acid or glutaconic acid.

In a second preferred embodiment of the method, an alkyl halide, such as 2-bromopropionic acid, is reacted with a THP^+ salt in the presence of a base.

Alternatively, there are many alkyl halides, which contain a hydrophilic group, which could be used. These will be readily apparent to those skilled in the art.

In a third preferred embodiment of the method, a phosphonic acid, such as vinylidene-1,1-diphosphonic acid, is reacted with a THP^+ salt in the presence of a base.

Preferred examples of compounds of formula (I) and/or formula (II) include the mono-substituted and di-substituted adducts of THPX and acrylic acid or of THPX and 2-bromopropionic acid.

The reaction may be performed at elevated temperature and under an inert (e.g. nitrogen) atmosphere.

It will be appreciated that for phosphonium compounds of formula (I) or formula (III) where n is less than 3, and for phosphine compounds of formula (II) where n is less than 3, the compounds will contain at least one methylol group. Further reaction of such compounds with other

substitutents is possible; either at the phosphorus atom or at the -CH_2OH group. For example, a condensation reaction product of the phosphonium compounds with, *inter alia*, urea, thiourea, dicyandiamide, melamine or guanidine may be formed by such further reaction.

For phosphonium compounds of formula (III), where M is an amine radical, it will be appreciated that further reaction with other substituents is possible at the amine of the phosphonium compound. The amine substituent may include, in addition to a quaternised amine radical, compounds selected from silicones. The silicones are preferably aminosilicones. For example, aminosilicones such as those available under the registered trade mark Rhodorsil®.

Compounds of formula (II) may be formed when a hydroxymethyl group is removed from a phosphonium compound of formula (I). Removal of a hydroxymethyl group can occur due to hydrolysis of a phosphonium compound. Hydrolysis can arise due to the addition of water or an increase in pH.

In a fourth aspect, the present invention provides the use of compounds of formula (I) and/or formula (II) in applications including scale inhibitors, scale dissolvers including iron sulphide dissolvers, corrosion inhibitors, chelating agents, flame retardants, disinfectants, in the surface modification of a wide variety of organic and inorganic substrates e.g. metals and natural or synthetic polymers, as ion exchangers, cement additives, adhesion promoters or gelatine hardening agents for use in, for example, photographic applications.

The compounds can also be used as cross linking agents e.g. in leather tanning. The compounds can also be used as pretanning agents, tanning or retanning agents, as cross-linking agents for leather finishes such as

casein or polyurethane-based finishes and as fixing agents for dyes and amino-derivatives (e.g aminosilicones or amine-derivatised dyes) on to wool, polyester, polyamide or leather substrates.

The compounds can also be used for leather tanning in combination with, pre-blended with, co-applied with or sequentially applied with, other pre-tanning agents such as syntans, aldehydes, THPX or oxazolidine; organic tanning agents such as THPX, aldehydes, oxazolidine, dialdehyde starch or polymeric dialdehydes; mineral tannins such as salts of chromium (III), titanium, zirconium, aluminium or iron; vegetable tannins, both hydrolysable and condensed tannins, such as tara, mimosa, sumac or quebracho; bating enzymes; pickling acids/salts; pickle replacements such as Rhodia ECOETS™; protein fillers; all types of syntans, including replacement, auxiliary, neutralising and chrome syntans; resins such as acrylics, styrene/maleics or nitrogen based resins; dyes including direct, reactive and premetallised dyes; fat liquors including anionic, nonionic, cationic, sulphited, sulphated, natural and synthetic types; water proofing agents; oil tannages such as cod oil; splitting/shaving aids such as colloidal silicates; other finish cross linkers such as aliphatic isocyanates, aziridine or carbodiimide.

The advantages of using the phosphonium compounds of formula (I) and/or the phosphine compounds of formula (II), in particular compounds which are the reaction product of THPX, a base and acrylic acid, include lower residual free formaldehyde levels in wet white and crusted skins and in finished leather; whiter and fuller skins and reduced grain tanning, giving a more versatile leather

In addition, the phosphonium and/or phosphine compounds, of formulas (I) and (II) respectively, exhibit synergy with mineral tanning agents and display dye enhancement with, for example, premetallised dyes. One

particular aspect of the invention is that the phosphonium and/or phosphine compounds exhibit enhanced compatibility with retannage chemicals, particularly sulphited fat liquors. Wet white leather which has been tanned using compounds of formula (I) and/or formula (II) can be retanned by conventional methods to produce a wide variety of leather skins. The skins are more tolerant to variations in retannage processes for example fat liquor selection is less critical than with conventional tannages.

The compounds can also be used for dye enhancement in textiles.

Phosphonium compounds of formula (I) and/or phosphine compounds of formula (II) can also be used as biocides, for example, as bactericides, fungicides, slimicides, algicides and anti-protozoals in the treatment of water systems.

The water systems to be treated in accordance with the present invention include oilfields, cooling towers, reverse osmotic processes, paper processing plants, non-potable water sources, as well as other industrial applications in which the biocidal treatment of water is necessary.

The present invention also provides the use of compounds of formula (I) and/or formula (II) as preservatives to prevent microbial spoilage of products susceptible to said spoilage.

Preferably, the products to be preserved comprise functional fluids, slurries, emulsions, suspensions and homogeneous solutions, for example, drilling fluids, completion fluids, fracturing fluids, clay slurries, kaolin slurries, silica slurries and calcium carbonate slurries.

The present invention further provides the use of compounds of formula (I) and/or formula (II) as disinfectants.

In the practice of the present invention, the compounds of formula (I) and/or formula (II) may be used in admixture with one or more surfactants. The surfactants may be anionic, cationic, non-ionic or amphoteric.

The present invention still further provides the use of compounds of formula (I) and/or formula (II) in admixture with other water treatment chemicals comprising at least one of scale inhibitors, corrosion inhibitors, dispersants, antifoams, wax inhibitors, asphaltene inhibitors, naphthenate inhibitors, oxygen scavengers, polyelectrolytes, scale dissolvers (including dissolvers for iron sulphide scale) and further biocides. Said further biocides may include poly-quaternary ammonium compounds such as WSCP; quaternary ammonium compounds such as benzalkonium chloride; mono-or poly-aldehydes, such as, formaldehyde and glutaraldehyde; isothiazolones such as chloromethylisothiazolinone (CIT), methylisothiazolinone (MIT), 1,2-benzisothiazolin-3-one (BIT) or CIT/MIT blends; oxidising biocides such as hydrogen peroxide, peracetic acid, chlorine, bromine, chlorine dioxide; halogenated organics such as 2-bromo-2-nitropropane-1,3-diol, 2,2-dibromo-3-nitrilopropionamide or 2,2-dibromo-2-nitroethanol; thio-carbamates; or polymeric biguanidines.

Preferred embodiments of the invention will now be illustrated, by way of the following examples.

Example 1

This Example illustrates the preparation of reaction products of tetrakis(hydroxymethyl)phosphonium chloride (THPC) and acrylic acid.

THPC (80% w/w, 238.4g, 1.0mol, 1 equiv), acrylic acid (80% w/w, 90.45g, 1.0mol, 1 equiv.) and water (600g) were charged to a 1-litre jacketed reaction vessel under nitrogen, to give a solution of pH 0 to 1. Sodium hydroxide solution (47% w/w, 110g) was added to the reactants over a period of 10 minutes during which the temperature reached 44°C. The pH of the solution was found to be 7.5.

The reactants were heated to 48°C for 6 hours before cooling. ^{31}P-NMR showed 62% mono-substituted product, 19% di-substituted product and 18% unreacted THPC (and THP acetate) by area. ^{1}H-NMR showed less than 1% unreacted acrylic acid remaining.

Further acrylic acid (80% w/w, 9.0g, 0.1mol, 0.1 equiv.) and sodium hydroxide solution (47% w/w, 0.48g) was charged to the reactor and the contents were heated at 48°C for 5 hours, after which the reaction mixture was cooled to room temperature. ^{31}P-NMR showed 69% mono-substituted product, 22% di-substituted product and 9% unreacted THPC (and THP acetate). ^{1}H-NMR showed less than 1% unreacted acrylic acid remaining.

The pH of the solution was adjusted to 4 using 36% hydrochloric acid.

The reactor was emptied and the solution stripped on a rotary evaporator using a divac pump to azeotropically remove formaldehyde, adding small amounts of water every hour for 7 hours. The product was stripped further using an oil pump.

The solids (266g) were dissolved in 173g of water to give a 50% w/w solution of mono-and di-substituted products.

Example 2

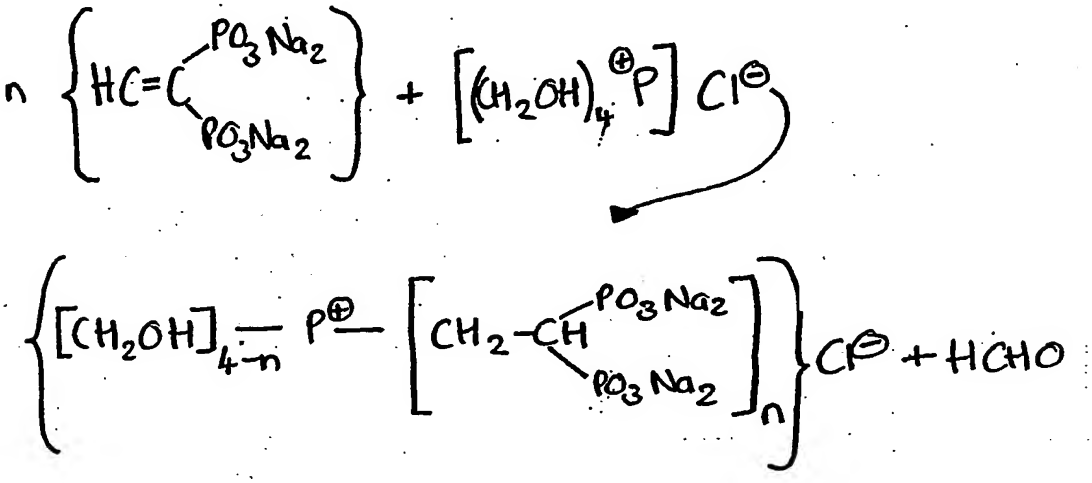
This Example shows an improved preparation of reaction products of THPC and acrylic acid compared to that of Example 1.

THPC (240g, 80%w/w, acrylic acid (77g, 99%) and water (600g) were added to a 1-litre flask fitted with condenser, temperature probe, nitrogen inlet and dropping funnel. Sodium hydroxide solution (100g, 47% w/w) was added dropwise over 60 minutes, ensuring that the temperature did not rise above 40°C. The reaction was allowed to stir at 50°C for 4.5 hours.

The ^{31}P-NMR spectrum, at this point, showed unreacted THP, so more acrylic acid (15g) was added and the reaction mixture heated for a further 3 hours. The water was stripped over 3.5 days on a rotary evaporator to eliminate formaldehyde. The final product contained 70.4% THPC/AA mono-substituted adduct, 28.2% di-substituted adduct and 1.6% tri-substituted adduct. No free, unreacted, THPC was present.

Example 3

This Example illustrates the preparation of reaction products of tetrakis(hydroxymethyl)phosphonium chloride (THPC) and vinylidene-1,1-diphosphonic acid (VDPA) tetra sodium salt.



Vinylidene-1,1-diphosphonic acid tetrasodium salt (VDPA, 400g, 0.79mol, 55%ww/w) was added to a solution of tetrakis-hydroxymethyl phosphonium chloride (THPC, 200g, 80%w/w, 0.79mol) and water (500ml) in a 3-necked, 2-L round bottomed flask. The mixture was heated under a nitrogen atmosphere with stirring to 75-80°C for 3.5 hours.

A sample was then taken and analysed by ^{31}P-NMR. This showed that all of the VDPA had reacted. There was also evidence of a small amount of oxidation of THPC to THPO.

A further 20g of VDPA was added to the reactor, which was maintained at 75°C for a further 2.5 hours. The reactor was then cooled to room temperature and stored under an inert atmosphere overnight. A sample was then taken and analysed by ^{31}P-NMR. A small trace of THP was detected.

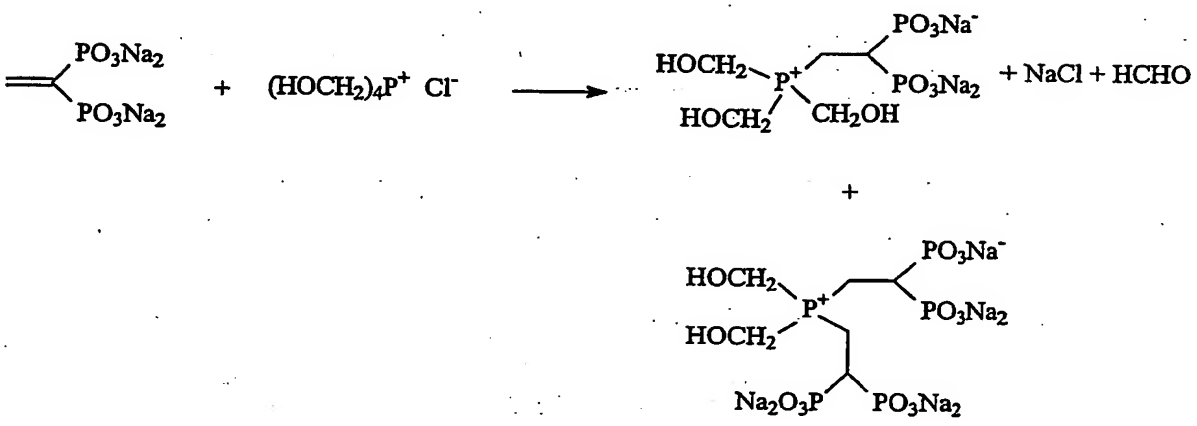
A further 15g of VDPA was added to the reactor, which was then heated to 75°C for 4 hours. After which, analysis by ^{31}P-NMR showed a small trace of THP still remained. The reaction was complete. The final composition of the reaction was 79% product, 4% of the di-addition product, 9% oxidation, 2%THP and 2.6% unreacted VDPA.

The mixture was cooled to room temperature and the pH of the product was adjusted from pH8 to pH6 with concentrated hydrochloric acid. The product was then placed on a rotary evaporator to remove water and formaldehyde. Water was continually added back to the flask to help azeotrope out any remaining formaldehyde, this process was continued for three 7-hour days.

The resulting product was a viscous colourless liquid (781g). The residual formaldehyde content was measured to be 2.3%w/w. The product was estimated to be 40%w/w and was diluted to give a 25%w/w solution in water.

Example 4

This Example further illustrates the preparation of reaction products of tetrakis(hydroxymethyl)phosphonium chloride (THPC) and vinylidene-1,1-diphosphonic acid (VDPA) tetrasodium salt.



Vinylidene-1,1-diphosphonic acid tetrasodium salt (VDPA, 442g, 0.8mol, 50%w/w) was added to a solution of tetrakis-(hydroxymethyl) phosphonium chloride (THPC, 100g, 80%w/w, 0.4mol) and water (500ml) in a 3-necked, 2-L round bottomed flask. The mixture was heated under a nitrogen atmosphere with stirring to 75-80°C for 7.5 hours. The reaction mixture was then cooled to room temperature and stored overnight under an inert atmosphere.

A sample was taken and analysed by ^{31}P-NMR. The spectrum showed that 43% of the VDPA was unreacted, 11% of the THPC had been oxidised to THPO and that there was 45% of the mono addition product.

A further 100g of THPC was added to the reactor, which was heated to 75°C for 4 hours. Analysis by ^{31}P-NMR showed all the VDPA had

reacted to give a mixture of the mono- (64%) and di- (36%) addition products.

Another 100g of VDPA was added to the reactor, which was maintained at 75°C for 4 hours. The reaction mixture was cooled to room temperature and stored overnight under an inert atmosphere. Analysis by ^{31}P-NMR showed that there was no residual VDPA, and that there was 57% dimer and 43% of the mono addition product.

A further 20g of VDPA was added to the reactor, which was again heated to 75°C for 4 hours. A sample was taken and analysed by ^{31}P-NMR, no unreacted VDPA was present. The proportion of the dimer had increased to 65% leaving 35% of the mono addition product. The proportion of dimer did not change with further heating and the reaction was concluded as being complete.

The product was placed on a rotary evaporator to remove water and formaldehyde. The resulting product was a mobile colourless liquid with a pH of 7. The moisture content was measured as 23.5%w/w.

The NMR integrals give a ratio of monomer : dimer by area. When these areas are converted into %w/w the product was calculated to be 74%w/w dimer and 26%w/w monomer.

It will be appreciated that examples 1 to 4 can be carried out in polar organic solvents.

Example 5

This Example shows the use of a product obtained according to the invention as a tanning agent using conventional tanning technology.

40g of pickled ovine skin
3g sodium chloride and water to give 100% float
0.2g of sodium formate
Rotated for 1 hour.
pH measured as 3.2

Next, 1.6g of a 1:1 THPC/acrylic acid adduct, with an activity of 17%, as determined by iodine titration, was added to give a percentage offer of 4% product.

This was rotated for 3 hours to obtain good penetration (as determined by a selenium indicator previously used with other phosphonium based tanning agents).

Following this, the float was basified gradually by adding 1%(0.4g) sodium bicarbonate and rotated for 30mins between each basification (2 basifications in total).

The final pH after basification was measured as pH 6.0

The shrinkage temperature was measured by standard techniques and a value of 67°C was obtained.

By applying the product at a higher pH, eg.4.5, a shrinkage temperature of 71°C was obtained.

The wet white produced using the THPC/acrylic acid adduct was whiter and fuller than that usually produced by conventional phosphonium tannages and, upon drying, produced a more malleable skin.

Example 6

This Example shows a further use of a product obtained according to the invention as a tanning agent using conventional tanning technology.

Bovine pickled pelt (100g)
8% sodium chloride and water to give 100% float (be° ~ 6)
0.75% sodium bicarbonate
30 minutes rotation-allow to adjust to float pH5

Next 3% tanning agent, made according to Example 3, was added and left for 90 minutes to allow penetration of the pelt. The shrinkage temperature was measured by standard techniques and a value of 65°C obtained.

Basification of the float to pH 6.5 was undertaken by adding 1% sodium bicarbonate at 30 minute intervals (sodium bicarbonate was added twice). The shrinkage temperature was now 68°C.

After leaving to rotate overnight the selenium indicator response was even and dark throughout (this indicates a good "equilibrium tannage"), the leather was flat and tight, and the shrinkage temperature was 76-77°C.

Example 7

This Example shows, using a standard quantitative suspension test, the use as a biocide of a product obtained according to the invention.

Tetrakis(hydroxymethyl)phosphonium sulphate (THPS) and a 1:1 THPC/acrylic acid product (as per Example 1 above) were each evaluated as 25% active products (300 ppm of product with a 3 hour contact period) against a mixed consortium general aerobic bacteria population. The results are expressed as log reductions of viable bacteria:

Product	Log reduction
THPS	5.2
1:1 THPC/acrylic acid adduct	4.7

Example 8

The Example further shows, using a standard quantitative suspension test, the use as a biocide of a product obtained according to the invention.

THPS (75% active) and the product of Example 1 above were each evaluated against a general aerobic bacterial population (200ppm of product with a 3 hour contact period) in paper white water. The results are expressed as log reductions of viable bacteria:

Product	Log Reduction
THPS	7.3
1:1 THPC/acrylic acid adduct	7.3

Example 9

This Example shows, using a standard quantitative suspension test, the use as a biocide of a product obtained according to the invention.

The product of Example 2 was used in this example and is the reaction product of tetrakis(hydroxymethyl) phosphonium chloride (THPC) and acrylic acid. The product was shown by iodine filtration to be 37% active, to have a mono:di:tri substituted species ratio of 83:4:11 and to contain 2.5% free THPC. This product was compared to THPS.

THPS and the product described above were each evaluated against a general aerobic bacterial population (37.5 ppm of active product with a 24 hour contact period). The results are expressed as log reductions of viable bacteria:

Product	Log Reduction
THPS	7.3
THPC/acrylic acid adduct	7.3

Example 10

This Example shows the use as an iron sulphide dissolver of a product obtained according to the invention.

In this Example:

THPC = tetrakis(hydroxymethyl)phosphonium chloride

AA = acrylic acid

Three screw-top glass jars were charged with 100g of the following 1:1 THPC-Acrylic Acid adduct (THPC-AA) solutions:

1. 20g of 1:1 THPC-AA and 80g deionised water;
2. 20g of 1:1 THPC-AA and 79g deionised water and 1g ammonium chloride;
3. 20g of 1:1 THPC-AA and 13.3g BRIQUEST® 543-25S* and 66.7g of deionised water.

(*25% Diethylenetriaminepentakis(methylenephosphonate, sodium salt))

BRIQUEST is a Registered Trade Mark.

Into each solution was accurately weighed about 3g of an oilfield iron sulphide scale (from a water injection system). The jars were each equipped with a magnetic follower and stirred for 20hrs in a 50°C water bath. Each solution was then filtered through a pre-weighed filter paper. The residues were washed with water and with acetone. The filter paper and remaining solids were then allowed to dry at room temperature to a constant mass before re-weighting, to give a weight loss. The filtered solutions were also analysed for iron content using the total iron method on a Hach DR2000 Spectrophotometer.

Results

	Solution	Start Wt (g)	Final Wt (g)	Wt Loss (g)	Wt Loss (%)	Iron in Solution (ppm)
(1)	THPC-AA	3.00	1.94	1.06	35	550
(2)	THPC-AA/NH_4^+	3.07	1.05	2.02	66	3400
(3)	THPC-AA/BRIQUEST® 543-25S*	3.11	1.13	1.98	64	3420

*See above

In a comparative experiment, a blank system (just water) gives a weight loss of 24% and zero iron in solution.

CLAIMS

1. A phosphonium compound having the general formula (I):

$$\left[Y_n P^{\oplus} (CH_2OH)_{4-n} \right] X^- \qquad (I)$$

wherein n is a positive integer of from 1 to 4; X is an anion; and Y is an organic residue including a hydrophilic group.

2. A phosphine compound having the general formula (II):

$$Y_n P (CH_2OH)_{3-n} \qquad (II)$$

wherein n is a positive integer of from 1 to 3; and Y is an organic residue including a hydrophilic group.

3. A compound according to Claim 1 or Claim 2 where Y is selected from unsaturated or saturated, aromatic or aliphatic, derivatives of C_1 to C_{10} carboxylic acids, phosphonic acids, acid phosphates, sulphonic acids and monohydric or polyhydric alcohols.

4. A compound according to Claim 1 or Claim 2 where Y is selected from C_1 to C_{10} groups containing polyethylene glycol and/or polypropylene glycol moieties.

5. A compound according to Claim 1 and to Claims 3 or 4 when dependant upon Claim 1, in which X is chloride, sulphate, bromide, iodide, phosphate, acetate, oxalate, citrate, borate, chlorate, nitrate, fluoride, carbonate or formate.

6. A compound according to Claim 1 or Claim 2 which is the reaction product of a tetrakis(hydroxyorgano) phosphonium salt, a base and an unsaturated or saturated, aromatic or aliphatic, C_1 to C_{10} carboxylic acid, phosphonic acid, sulphonic acid, acid phosphate or monohydric or polyhydric alcohol.

7. A compound according to Claim 6 which is the reaction product of a tetrakis(hydroxyorgano) phosphonium salt, a base and an unsaturated carboxylic acid, or an ester or salt of an unsaturated carboxylic acid.

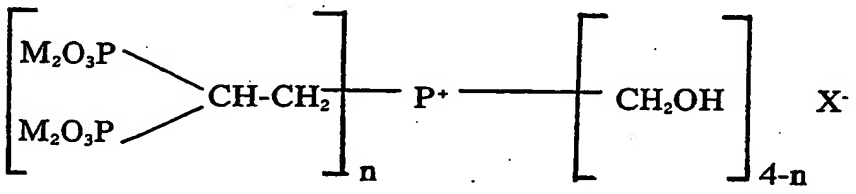
8. A compound according to Claim 1 or Claim 2 which is the reaction product of a tetrakis(hydroxyorgano)phosphonium salt, a base and an alkyl halide containing at least one reactive halogen and at least one group which imparts hydrophilic character.

9. A compound according to Claim 8 in which the substituted alkyl halide comprises from one to ten carbon atoms.

10. A compound according to Claim 8 or Claim 9 in which the group which imparts hydrophilic character is derived from an unsaturated or saturated, aromatic or aliphatic, C_1 to C_{10} carboxylic acid, phosphonic acid, sulphonic acid, acid phosphate or monohydric or polyhydric alcohol.

11. A compound according to Claim 1 or Claim 2 comprising the reaction product of a tetrakis (hydroxy-organo) phosphonium salt, a base and vinylidene-1, 1-diphosphonic acid (VDPA) or a salt or an ester of VDPA.

12. A compound according to Claim 11 when dependent on Claim 1, in which said compound has the general formula (III):



(III)

wherein M is hydrogen, an alkali metal, an alkaline earth metal, a polyvalent metal, ammonium or a quaternised amine radical and each M may be the same or different; X is an anion and n is a number having a positive average value of up to 4.

13. A compound according to Claim 12, in which M is a transition metal.

14. A compound according to Claim 13, in which M is copper, chromium, iron, titanium, or zirconium.

15. A compound according to Claim 12, in which M is aluminium.

16. A compound according to Claim 12, in which the quaternised amine radical is a salt derived from neutralisation with an amine.

17. A compound according to Claim 12 or Claim 16, in which the quaternised amine radical is triethanolamine.

18. A compound according to Claim 13, in which the quaternised amine radical is a quaternary ammonium base.

19. A compound Claim 18, in which the quaternary ammonium base is tetrabutyl ammonium hydroxide.

20. A compound according to any one of Claims 12 to 19, in which X is chloride, sulphate, bromide, iodide, phosphate, acetate, oxalate, borate, chlorate, nitrate, fluoride, carbonate or formate.

21. A compound according to any one of Claims 6 to 20, in which the tetrakis(hydroxyorgano)phosphonium salt is a tetrakis(hydroxymethyl) phosphonium salt of formula THPX.

22. A compound according to Claim 21 in which the tetrakis(hydroxymethyl) phosphonium salt is tetrakis(hydroxymethyl) phosphonium chloride (THPC), sulphate (THPS) acetate (THPA) or phosphate (THPP)

23. A compound according to any one of Claims 3, 6, 7 and 10 in which the unsaturated carboxylic acid is a mono-carboxylic acid.

24. A compound according to Claim 23, in which the acid is acrylic acid.

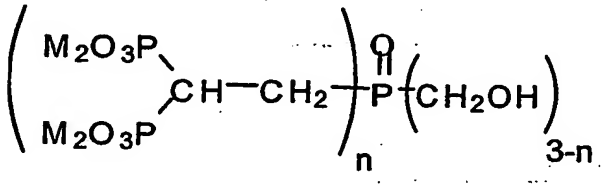
25. A compound according to Claim 23, in which the acid is methacrylic acid, crotonic acid, isocrotonic acid, angelic acid or tiglic acid.

26. A compound according to any one of Claims 3, 6, 7 and 10, in which the unsaturated carboxylic acid is a di-carboxylic acid.

27. A compound according to Claim 26, in which the acid is maleic acid, fumaric acid, citraconic acid, mesaconic acid, itaconic acid or glutaconic acid.

28. A phosphine oxide consisting essentially of an oxidation product of the phosphonium compound as claimed in Claim 11 or Claim 12.

29. A phosphine oxide as claimed in Claim 28, in which said oxide is represented by the general formula (IV):



(IV)

wherein n has a positive average value of from 1 to 3; and M has the same significance as in Claim 12.

30. A method for the production of a compound as claimed in Claim 1, Claim 2 or Claim 12 which comprises reacting a tetrakis(hydroxyorgano) phosphonium salt and a base, with an organic compound including a hydrophilic group.

31. A method according to Claim 30 in which the organic compound is an unsaturated or saturated, aromatic or aliphatic, C_1 to C_{10} carboxylic acid, phosphonic acid, sulphonic acid, acid phosphate or monohydric or polyhydric alcohol

32. A method according to Claim 30 or Claim 31 in which the organic compound is an unsaturated carboxylic acid, or an ester or salt of an unsaturated carboxylic acid.

33. A method according to Claim 30 in which the organic compound is an alkyl halide containing at least one reactive halogen and at least one group which imparts hydrophilic character.

34. A method according to Claim 33 in which the substituted alkyl halide comprises from one to ten carbon atoms.

35. A method according to Claim 34 in which the alkyl halide is 2-bromo-propionic acid.

36. A method according to Claim 33 to 35 in which the group which imparts hydrophilic character is derived from an unsaturated or saturated, aromatic or aliphatic, C_1 to C_{10} carboxylic acid, phosphonic acid, sulphonic acid, acid phosphate or monohydric or polyhydric alcohol.

37. A method according to Claim 36 35 in which the group which imparts hydrophilic character is derived from C_1 to C_{10} groups containing polyethylene glycol and/or polypropylene glycol moieties.

38. A method according to Claim 31, 32 or 36 in which the unsaturated carboxylic acid is a mono-carboxylic acid.

39. A method according to Claim 38, in which the acid is acrylic acid.

40. A method according to Claim 38, in which the acid is methacrylic acid, crotonic acid, isocrotonic acid, angelic acid or tiglic acid.

41. A method according to Claim 31, 32 or 36 in which the unsaturated carboxylic acid is a di-carboxylic acid.

42. A method according to Claim 41, in which the acid is maleic acid, fumaric acid, citraconic acid, mesaconic acid, itaconic acid or glutaconic acid.

43. A method according to Claim 30 or Claim 31 in which the organic compound is vinylidene-1, 1-diphosphonic acid (VDPA).

44. A method according to any one of Claims 30 to 43, in which the tetrakis(hydroxyorgano) phosphonium salt is tetrakis(hydroxymethyl) phosphonium chloride (THPC), sulphate (THPS) acetate (THPA) or phosphate (THPP).

45. A method according to any one of Claims 30 to 44, in which the reaction is carried out at an elevated temperature and under an inert atmosphere.

46. A method according to any one of Claims 30 to 45, in which reaction product contains at least one methylol group, whereby further reaction at the phosphorus atom or at a methylol group can occur.

47. A method according to Claim 46, in which said further reaction forms a condensation product of said phosphonium compound with urea, thiourea, dicyandiamide, melamine or guanidine.

48. A method as claimed in Claim 43 when dependant upon Claim 12, in which M is an amine in the reaction product, whereby further reaction at the amine can occur.

49. A method as claimed in Claim 48, in which the amine comprises a silicone.

50. A method as claimed in Claim 49, in which the silicone is an amino silicone.

51. The use of compounds according to any one of Claims 1 to 29, in which said compounds are used as scale inhibitors, scale dissolvers, corrosion inhibitors, chelating agents, flame retardants, disinfectants, in the surface modification of organic or inorganic substrates, as ion exchangers, cement additives, adhesion promoters or gelatine hardening agents.

52. The use of compounds according to Claim 51, in which the organic or inorganic substrates are metals or natural or synthetic polymers.

53. The use of compounds according to any one of Claims 1 to 29, in which said compounds are used as cross-linking agents in leather tanning.

54. The use of compounds according Claim 53, in which said compounds are used in combination with other pre-tanning agents, other organic tanning agents, mineral tannins, vegetable tannins, bating enzymes, pickling acids or salts, pickle replacements, syntans, resins, dyes, fat liquors, water proofing agents, oil tannages, splitting/shaving aids or other finish crosslinkers.

55. The use of compounds according to any one of Claims 1 to 29, 53 or 54, in which said compounds are used as pretanning, tanning or retanning agents, cross-linking agents for leather finishes, fixing agents for dyes or amino-derivatives on to wool, polyester, polyamide or leather substrates.

56. The use of compounds according to Claim 55, in which the leather finishes are casein finishes or polyurethane-based finishes.

57. The use of compounds according to Claim 55, in which the amino-derivatives are aminosilicones or amine-derivatised dyes.

58. The use of compounds according to any one of Claims 1 to 29, in which said compounds are used as biocides.

59. The use of compounds according to any one of Claims 1 to 29 or 58 as bactericides, slimicides, algicides, fungicides or as anti-protozoals in the treatment of water systems or of industrial processes which use water.

60. The use of compounds according to any one of Claims 1 to 29, 58 or 59, as a preservative to prevent microbial spoilage of a product susceptible to said spoilage.

61. The use of compounds according to Claim 60, in which the product is a functional fluid, a slurry, an emulsion, a suspension or a homogeneous solution.

62. The use of compounds according to Claim 61, in which the functional fluid is a drilling fluid, a completion fluid or a fracturing fluid.

63. The use of compounds according to Claim 62, in which the slurry is a kaolin slurry, a silica slurry or a calcium carbonate slurry.

64. The use of compounds according to any one of Claims 58 to 63, in which the compound is admixed with one or more surfactants.

65. The use of compounds according to any one of Claims 58 to 64, in which the compound is admixed with one or more water treatment chemicals.

66. The use of compounds according to Claim 65, in which the water treatment chemical is selected from the group consisting of scale inhibitors, corrosion inhibitors, dispersants, antifoams, wax inhibitors, asphaltene inhibitors, naphthenate inhibitors, oxygen scavengers, polyelectrolytes, scale dissolvers and further biocides.

67. The use of compounds according to Claim 66, in which said further biocides are poly-quaternary ammonium compounds, quaternary ammonium compounds, mono-aldehydes or poly-aldehydes, isothiazolones, oxidising biocides, halogenated organics, bromo thiocarbamates, or polymeric biguanidines.

68. The use of compounds according to any one of Claims 1 to 29, in which said compounds are used as iron sulphide dissolvers.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 02/03907

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 D06M13/00 C07F9/54 C07F9/50

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 C07F D06M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, WPI Data, BEILSTEIN Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 755 457 A (CARLSON R) 28 August 1973 (1973-08-28) examples 1-4	1,3,5,6, 21,22, 51,52
X	DE 10 45 401 B (HOECHST AG) 4 December 1958 (1958-12-04) cited in the application column 2, line 53 -column 3, line 2; examples 1-7	1-3, 5-10, 21-27, 51,52,58
X	US 2 937 207 A (ERHARD WOLF ET AL) 17 May 1960 (1960-05-17) column 3, line 18 - line 23; examples 2,6,9,10,15,16,21,22,26,30-32,34	1,2, 5-10, 21-27, 51,52,58

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 January 2003	31/01/03

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Koessler, J-L

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INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 02/03907

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/GB 02 /03907

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-3, 5-10, 21-27, 30-36, 38-42, 44-47, 51-68

   Compounds of formula (I) or (II) wherein the hydrophilic group of Y is a carboxylic acid or a derivative thereof.

2. Claims: 1-3, 5, 6, 8-22, 28-31, 33, 34, 36, 43-68

   Compounds of formula (I) or (II) wherein the hydrophilic group of Y is a phosphonic acid or a derivative thereof.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 02/03907

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